# *Hydraulic Actuator Project*

- *Stakeholder meeting held 7-8 October in Los Angeles; 58 attendees representing aircraft and actuator OEMs, seal manufacturers, Air Force and NAVAIR cognizant authorities, HCAT, Caterpillar and thermal spray vendors*
- *Recent activities reviewed and then draft Joint Test Protocol discussed and revised*
- *JTP divided into two parts:*
  - *Part I: Coupon Testing*
  - *Part II: Functional Rod/Seal Testing*
- *Keith Legg prepared latest versions resulting from meeting*

# Report Documentation Page

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13. SUPPLEMENTARY NOTES
**23rd Replacement of Hard Chrome Plating Program Review Meeting, November 18-19, 2003, Cape Canaveral, FL. Sponsored by SERDP/ESTCP.**

14. ABSTRACT

15. SUBJECT TERMS

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# Actuator JTP: Coupon Testing

- Substrate materials to be evaluated:
  - 4340 steel (180-200 ksi)
  - PH15-5 stainless steel (155 ksi)
  - Ti-6Al-4V (130 ksi)
- Coatings to be Evaluated:
  - WC-20Ni7Cr6C (Praxair LW105)
  - WC-10Co-4Cr (per BAC 5851, Type XVII)
  - $Cr_3C_2$-25NiCr (per BAC 5851, Type XVI)
  - Tribaloy 400 (per BAC 5851, Type XV)
  - Another alloy coating (perhaps Ni-Ti shape memory alloy)
  - Hard chrome plate per QQ-C-320 (not superchrome)
- Tensile testing is to be conducted on substrate materials to verify properties

# Actuator JTP: Coupon Testing

- **Fatigue Testing**
  - Axial per ASTM 466-96, hourglass sample
  - Environment: lab air and NaCl
  - Coating thicknesses (after grinding): 0.003" and 0.010"
  - R = -1; high load at 85% of yield; low load to give 1 million cycles; intermediate load

*Table **Error! No text of specified style in document.**-1. Fatigue test matrix. (Note: identical matrix for each substrate alloy.)*

| Coating | Thickness (mil) | Environ-ment | # of specimens 4340 | # of specimens PH 15-5 | # of specimens Ti 6Al4V |
|---|---|---|---|---|---|
| Uncoated | | Air | 20 | 20 | 20 |
| Uncoated, unpeened | | Air | 20 | 20 | 20 |
| EHC | 10 | Air | 10 | 10 | 10 |
| WC-CoCr | 10 | Air | 10 | 10 | 10 |
| WC-CrNiC | 10 | Air | 10 | 10 | 10 |
| $Cr_3C_2$-NiCr | 10 | Air | 10 | 10 | 10 |
| T-400 | 10 | Air | 10 | 10 | 10 |
| | | **Total** | **90** | **90** | **90** |
| | | | | **Grand total** | **270** |

# Actuator JTP: Coupon Testing

- *Integrity Testing*
  - *Hollow "big-bar" starting at 50% of yield strength and continuing up to 106% of YS or coating failure*
  - *Four-point bend testing*
- *Corrosion Testing*
  - *ASTM B117 neutral salt fog*
  - *ASTM G-85 sulfur dioxide*
  - *ASTM G-71 (or alternative) galvanic*
  - *Specimen shape: mostly 1" –dia. rods (grinding), some flats*
- *Fluid Immersion*
  - *Specimen shape: 1"-dia. Rods*
  - *Tests to be conducted with approximately 12 different chemicals including hydraulic fluids, cleaners, etchants, fuels, and decontaminants*

# Actuator JTP: Coupon Testing

- *Impact Testing*
  - *Gardner Impact (free-falling striker impacting on coating)*
  - *Gravelometry*
- *Environmental Hydrogen Embrittlement*
  - *ASTM F519 test (notched round bar)*
  - *4340 steel (280 ksi) and Ti-10-2-3*
  - *Test at 45% notch tensile strength in DI water and 5% NaCl solution*
- *JTP also includes quality control tests, appendices on coating process documentation, and Almen strip and temperature measurement procedures*

# Actuator JTP: Rod/Seal Testing

- *Testing to be done on NAVAIR Pax River test apparatus (shown in next slide)*
- *Substrate rods fabricated from PH13-8Mo stainless steel (220 ksi)*
- *Coatings to be evaluated are basically same as for coupon testing, except nanocrystalline Co-P alloy coatings will be included*
- *Different surface finishes to be evaluated*
- *Mating seals to include elastomeric O-ring seals and spring-energized PTFE seals provided by different seal manufacturers*

# *Pax River Test Apparatus*

**Test apparatus mounted in environmental chamber; consists of four rods with pair of seal blocks per rod**

**Primary seals in blue, secondary seals in magenta; two seal configurations per block and 16 seal configurations under test**